

Connection between discrete stochastic and continuous models in biology

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Swarming, a collective motion of many thousands of cells, produces colonies that rapidly spread over surfaces. A detailed cell- and behavior-based computational model of *M. xanthus* swarming [1] will be used in this talk to show that reversals of gliding direction are essential for swarming and that the reversal period predicted to maximize the swarming rate is the same as the period observed in experiments. This suggests that the circuit regulating reversals evolved to its current sensitivity under selection for growth achieved by swarming. Also, an orientation correlation function will be used to show that microscopic social interactions help to form the ordered collective motion observed in swarms [2].

Then a continuous limit will be described of a two-dimensional stochastic discrete model describing cells moving in a medium and reacting to each other through direct contact, cell-cell adhesion, and long range chemotaxis [3]. Contrary to classical Keller-Segel model, solutions of the obtained nonlinear diffusion equation do not collapse in finite time and can be used even when relative volume occupied by cells is rather large. A very good agreement was demonstrated between Monte Carlo simulations and numerical solutions of the obtained macroscopic nonlinear diffusion equation. Combination of microscopic and macroscopic models was used to simulate growth of structures similar to early vascular networks.

1. Wu, Y., Jiang, Y., Kaiser, D., and M. Alber [2007], Social Interactions in Myxobacterial Swarming, *PLoS Computational Biology* 3 12, e253.
2. Wu, Y., Jiang, Y., Kaiser, D., and M. Alber [2009], Periodic reversal of direction allows Myxobacteria to swarm, *Proc. Natl. Acad. Sci. USA* 106 4 1222-1227 (featured in the Nature News, January 20th, 2009, doi:10.1038/news.2009.43).
3. Lushnikov, P.P., Chen, N., and M.S. Alber [2008], Macroscopic dynamics of biological cells interacting via chemotaxis and direct contact, *Phys. Rev. E* 78, 061904.